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Previous reports:	None
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The results and conclusions in this report are based on an investigation conducted over one year. The conditions under which the experiments were carried out and the results obtained have been reported with detail and accuracy. However, because of the biological nature of the work, it must be borne in mind that different circumstances and conditions could provide different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

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GROWER SUMMARY

Headline

In the first year of this trail, the use of compost teas on lavender and choisya plants has not resulted in any benefits in terms of plant growth, quality or disease control.

Background and expected deliverables

Growers of ornamental crops have access to a limited (and decreasing) number of effective fungicides so there is a continuing need to seek new ways of improving crop growth and health. Compost teas have been used for several years in the USA to stimulate healthy crop growth and to reduce the incidence and severity of disease. Around 50 UK growers are also beginning to experiment with compost teas. There has been limited scientific work published to prove the effectiveness of compost teas and the recommendations being supplied to growers relating to their use is rarely based on scientific evidence.

Compost teas defined

Compost teas can be defined as the product of showering or circulating water through compost (or a porous bag of compost suspended over or within an open tank) with the intention of maintaining aerobic conditions. The product of this method has also been termed 'aerated compost tea' and 'organic tea'. Most compost teas made in the UK and USA now are aerated during their production (or fermentation). They are therefore known as aerated compost teas. Most of the published scientific work which has examined compost teas has looked at non-aerated compost teas.

How to make compost teas

In order to make compost teas, a grower requires a fermentation vessel, compost and water. Nutrients may also be added prior to or following fermentation and additives can be added prior to application. Compost teas are generally made by mixing one volume of compost with between four to twenty volumes of water in an open or closed container. The mixture is stirred as it is made up, then it is left for between 12 hours and 3 days. During this period, aerated compost teas are stirred or aerated in different ways, depending on the type of brewer.

What can compost teas do?

Compost teas have been shown to help prevent and/or control a wide range of foliar diseases in glasshouse and field grown edible and ornamental crops. Examples of diseases controlled in this way include botrytis, leaf spots, root rots, mildews, rusts and scabs. It is important to note that control has not been

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achieved with all pathogens in all tests. The degree of disease control varies a great deal.

How do compost teas work?
The effects of compost teas depend on the live micro-organisms within them. In other words, if compost teas are heat sterilised, they tend to have little or no effect. The live micro-organisms within compost teas act as biological control agents.

There is an urgent need for independent scientific work to:
- Optimise production methods for compost teas
- Optimise application strategies for compost teas
- Assess the safety and minimise the risks to human health from the use of compost teas
- Determine the factors affecting efficacy of compost teas in order to further develop strategies for maximising efficacy

If successful strategies for the production and use of compost teas are developed, there is potential to reduce fungicide costs, to maintain or improve crop growth and health and to improve soil health in field grown crops.

Summary of project and main conclusions to date

Overall project aim
This work aims to answer key questions relating to the preparation, application and effects of compost teas on UK ornamental nurseries and to give growers practical information to enable them to use compost teas to best effect following basic scientific work and glasshouse/tunnel trials.

The specific objectives are as follows:

1. Test the effect *(on crop growth, health and presence/absence of disease*) of teas made using four reputable compost tea brewers available on the world market on two ornamental species under experimental glasshouse conditions.

Choisya ternata 'Sundance' and *Lavandula angustifolia* 'Imperial Gem' were the two species used.

The four compost tea brewers were:
- Liquid Compost Brewer obtained from Compost Tea Brewers Ltd
- Xtractor (Compara) obtained from Fargro Ltd
- System 25 obtained from Growing Solutions Inc
- Earth Tea Brewer obtained from EPM Inc

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2. Determine the effect *(on crop growth, health and presence/absence of disease*) of compost type on the quality and effects of the finished tea on choisya and lavender under experimental glasshouse conditions.

The four compost types tested were:
- CMC compost i, van Iersel
- CMC compost ii, a mixture of strawy cattle manure, greenwaste and grass clippings
- Greenwaste compost I
- Greenwaste compost II

3. Determine the effect *(on crop growth, health and presence/absence of disease*) of compost maturity on the quality and effects of the finished tea on choisya and lavender under experimental glasshouse conditions.

The four compost maturities were:
- CMC compost i, van Iersel
- Greenwaste immature
- Greenwaste mature
- Greenwaste very mature

4a. Determine the effect of brew constituents on the effects of compost teas

Four teas with different brew constituents were tested, these were as follows:
- Van Iersel Kit mixture (van Iersel compost + herbs + sugars + nutrients)
- Van Iersel compost + herb mix + sugars + nutrients
- CMC compost + herb mix + sugars + nutrients
- CMC compost + sugars + nutrients

Teas made in the above trials 1, 2, 3 and 4a were compared against application with plain water or a standard fungicide treatment.

4b. Determine the effect of additives on the effects of compost teas

5. Assess the characteristics (*pH, nutrient content, presence of beneficial organisms*) of compost teas used in trials carried out under Objectives 3 and 4.

6. Test teas made under the two best performing preparation systems (determined under objectives 1-4) on commercial nurseries. The effect of compost teas on the following will be determined:
- Crop growth and development (roots and shoots)
- Crop health (incidence/severity of diseases, presence of pests, pest damage and biological control agents)

- Soil/growing media health (based on respiration and hydrolytic enzyme activity).

7. Prepare a report based on work carried out in this study and an assessment of other important scientific work in the USA and Europe. The report will aim to:

- Briefly review relevant literature on compost teas since 2002
- Summarise the results obtained in the project
- Provide guidance to growers on the preparation and use of compost teas
- Determine research priorities for the future

Main conclusions to date

Trial 1 – the effect of teas made using four compost tea brewers

There were no differences between the growth of either lavender or choisya plants treated with fungicides, plain water or compost teas (made using four different brewers).

There were no differences in the amount of disease caused by botrytis on lavender plants or damage caused by red spider mite on choisya plants treated with fungicides, plain water or compost teas made using four different brewers.

Trial 2 – the effect of compost type on the quality and effects of the finished tea

<u>Plant quality</u>

Lavender plants treated with plain water or compost tea made from Van Iersel compost had significantly lower quality scores than those treated with fungicides.

<u>Flower spikes</u>

Lavender plants treated with compost tea made from Van Iersel compost or greenwaste compost ii had significantly fewer flower spikes than those treated with fungicides or greenwaste compost i.

<u>Dry weight</u>

Lavender plants treated with plain water or compost tea made from Van Iersel compost had lower dry weights than those treated with fungicides or compost tea made from CMC compost ii.

<u>Plant growth</u>

There were no significant differences between plants treated for any of the parameters measured on choisya plants (ie shoot dry weight, plant height, no. of shoots).

Disease incidence
Although the lavenders were infected with botrytis, there were no significant differences between treatments (ie plain water, fungicides or compost teas (made with four different brewers).

Microbiological tests showed that the numbers of total culturable bacteria recorded from compost tea brews in Trials 1 and 2 were usually within the range reported for disease suppressive compost teas.

There is published evidence to show that compost teas can in some cases improve crop growth and health and can reduce incidence and severity of disease in some situations. However, there is also published evidence to show that compost teas can have no effects, variable effects or even deleterious effects on plant growth or health. The results of Trials 1 and 2 were not therefore without precedent. Staff who carried out work during Trials 1 and 2 can find no reason to suggest that inappropriate protocols were devised for the work.

Trials 3 and 4a – the effect of compost maturity and brew constituents
These trials are in progress at SAC, Aberdeen. No differences are being observed between treatments at this stage. These trials will be allowed to run until early spring in order to determine whether differences can be detected between treatments.

Trial 4b (the effects of additives on the effects of compost teas) will be set up as soon as Trial 3 is complete.

Trial 6 - commercial nursery trials
Nursery trials on choisya, cordyline, county rose, heather, lavender and phygelius using the van Iersel Xtractor tea are now running up on four UK sites. The first assessments are due in the near future.

If positive effects of compost teas on plant growth or health are detected in any of the trials within this or related projects, microbial analysis of the effective tea will be carried out to determine whether differences exist between it and previously analysed teas which have had no effect.

The progress of this project and the trials within it will continue to be compared with current work on compost teas in other countries, especially the USA. Useful information will be incorporated into trial protocols in an effort to improve the effects of compost teas used in experimental work.

Financial benefits

There are no proven financial benefits from this work to date.

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Action points for growers

There are no action points for growers from this work to date.

SCIENCE SECTION

GENERAL INTRODUCTION

There is evidence that sprays based on compost extracts have been used for hundreds of years. Their use declined when pesticides became available in the 20th century, since pesticides tend to give better, more reliable control of most foliar diseases. However, recent increases in sustainable and organic farming and problems relating to pesticide use have led to a significant resurgence in interest in compost extracts and teas. In relation to this project, growers of ornamental crops have access to a limited (and decreasing) number of effective fungicides. Some ornamental crops suffer phytotoxicity symptoms when certain fungicides are applied, particularly during the propagation or young plant stage. There is a continuing need to seek new solutions for improving crop growth and health. A great deal of work has been done to develop improved methods for preparation and use of compost extracts and teas. Most of this work has been done in the USA and much of it by commercial companies rather than federal research institutes. The work and the key findings from it are outlined here.

The term "compost tea" has not always been associated with an aerated fermentation process. It is important to distinguish between compost teas prepared using aerated and non-aerated processes, therefore the terms aerated compost tea (ACT) and non-aerated compost tea (NCT) will be used in this report to refer to the two dominant compost fermentation methods. ACT will refer to any method in which the water extract is actively aerated during the fermentation process. NCT will refer to methods where the water extract is not aerated or receives minimal aeration during fermentation apart from during the initial mixing.

<u>Production of compost teas</u>
The production of aerated and non-aerated compost teas both involve compost being fermented in water for a defined time period. Both methods require a fermentation vessel, compost, water, incubation and filtration prior to application. Nutrients may be added prior to or following fermentation and additives or adjuVants may be added prior to application. Compost teas are generally made by mixing one volume of compost with between four to twenty volumes of water in an open or closed container. The mixture is stirred as it is made up, then it is left for between 12 hours and 3 days. During this period, NCT's are given minimal or no stirring. ACT's are stirred or aerated in different ways, depending on the type of brewer. Compost teas can be made in quantities ranging from a few litres to several thousand litres in a single batch depending on the size of the fermentation vessel.

<u>Effect on plant disease</u>
Compost teas have been shown to help prevent and/or control a wide range of foliar diseases in glasshouse and field grown edible and ornamental crops. A comprehensive account of diseases which have been fully or partially controlled through the application of compost teas or extracts under experimental conditions is given in Scheuerell and Mahaffee (2002). Examples of diseases controlled in this way include those caused by *Alternaria* spp., *Botrytis cinerea, Phytophthora infestans, Plasmopara viticola, Sphaerotheca* spp., *Uncinula necator* and *Venturia inaequalis*. It is important to note that control has not been achieved with all pathogens in all tests. Efficacy varies depending on the crop and experimental system.

Most of the published evidence to demonstrate control of foliar disease concerns NCTs or compost extracts. At present, there is a shortage of data which compares the efficacy of ACTs and NCTs in controlling foliar diseases. A recent study by Scheuerell and Mahaffee (personal communication) examined the role of aeration and three different compost types on the efficacy of compost teas for controlling powdery mildew (*Sphaerotheca pannos* var. rosae) on rose. All six compost teas significantly reduced powdery mildew in comparison to a control spray of water, but there was no difference in efficacy between ACTs and NCTs.

There are now several commercial companies in the USA, one in The Netherlands and one in the UK which are selling and promoting the use of machinery to make ACT's. However, there is little scientific evidence to demonstrate the efficacy of ACT's and there is almost no scientific evidence to show that they are any more effective in controlling disease than NCTs. The limited number of controlled studies which have been carried out to date are summarised in Scheuerell and Mahaffee (2002). Trials on a range of crops have shown that the effects of ACTs vary considerably. For example, no effect of ACT applications on early blight of tomato was observed; lettuce drop (several pathogens) was reduced in a summer but not a spring crop; post-harvest fruit rot of blueberries was significantly reduced, but this was offset by reduced yields. In conclusion, the impact of ACTs on plant health and crop yield can be crop specific and may depend on the experimental system and environmental conditions. General statements about the efficacy of ACTs cannot be made.

Compost teas are also being widely advertised and used on both organic and conventional farms (mainly in the USA, but also in Europe) as an inoculant to restore or enhance soil microflora (Diver, 1998). However, very little work has been done to quantify the benefits from using compost teas in this way. There has been some work carried out to determine the effects of NCTs on seedborne pathogens through seed treatment. There has also been limited work done on soilborne pathogens *in vitro*, but it is well known that successful disease control *in vitro* does not always translate to field conditions. Recent work has shown that fusarium wilt of pepper (*F. oxysporum* f.sp. *vasinfectum*) and cucumber (*F. oxysporum* f.sp. *cucumerinum*) was controlled by drenching NCT on to soil under greenhouse conditions. The mode of action of the NCT was investigated *in vitro* and it had a mycolytic effect on fusarium microspores and chlamydospores, which showed that destruction of the pathogen propagules could be important in disease suppression.

Potential effect on soil/growing media health

Soil health is central to any sustainable crop production system where reliance on synthetic fertilisers and pesticides is minimised, but it’s potential has not yet been fully explored. The health of a soil or growing medium has physical, chemical and biological components. The biological component of soil health depends on the numbers, diversity and health of the organisms including soil microflora present. Soil (and growing medium) health is associated with biological diversity and stability. It has been suggested that plant disease outbreaks can be regarded as indicators of instability and poor ecosystem health. It is therefore thought likely that there are links between soil (or growing medium) health, the ability of the biological community to suppress plant pathogens, populations of soil-borne plant pathogens and also disease incidence and severity.

Soil health monitoring is rarely practiced in Europe, but in some parts of the USA, farmers are using test kits to determine chemical, physical and biological components of soil health (eg Solvita, 2004). These have proved useful in demonstrating effects of management on soil health. Advice is widely given from several compost tea brewer manufacturers that compost tea drenches can improve the health of soils and growing media. However, at present, there is very little scientific evidence to demonstrate the impact which compost extracts or teas can have on soil health and the presence of beneficial microorganisms.

Potential problems with compost extracts and teas

At present, the main potential problem with compost teas (apart from reports of variable efficacy in controlling plant disease) appears to be the concern that fermenting compost could potentially support the growth of human pathogens. For example, faecal coliform and salmonella populations have been detected in the source compost, the NCT fermentation and on samples of field-grown broccoli and leeks sprayed with the NCT. Present evidence shows that pathogens can grow during the production of both ACTs and NCT's. However, the indications are that pathogen growth is not supported when ACTs or NCTs are prepared without fermentation nutrients. Further study of the potential for propagation of human pathogens is outside the scope of this project, although the intention is to monitor for the presence of fecal coliforms in the teas used in experimental work where time and resources permit.

Mode of action of compost teas

Compost teas sprayed on to plant leaves act on the leaf surface. The principal active agents in compost teas appear to be bacteria and fungi in the genera *Bacillus, Serratia, Penicillium* and *Trichoderma*, although other genera are involved. There is no single mechanism which explains the effects of compost extracts against foliar plant pathogens. It is possible to divide the effects of compost extracts into three categories:

- inhibition of spore germination
- antagonism and competition with pathogens
- induced resistance against pathogens

The main effects of compost extracts and teas appear to be associated with live microorganisms. Sterilised or micron filtered compost extracts have usually been shown to have significantly reduced activity against test pathogens. In a few cases, sterilised extracts have been shown to have limited activity against foliar pathogens. For example some chemicals produced by *Pseudomonas* spp. (eg siderophores) have been shown to exert a powerful chemical effect against other organisms. Antiobiotics have been shown to be produced by *Bacillus subtilis* and these inhibit the growth and germination of many fungal species.

The phenomenon of induced or acquired systemic resistance may also explain part of the mode of action of some compost extracts and teas. There is plenty of evidence to show that microorganisms (whether pathogenic or not) can induce plant defence responses. For example, when cucumber leaves are inoculated with the fungus *Colletotrichum lagenarium*, the infected leaves become resistant not only to attack by *C. lagenarium*, but also towards all other foliar pathogens. Knowledge of this phenomenon and its potential for control of plant pathogens is limited at this time.

Factors affecting efficacy of compost teas

There is sufficient information to show that in some cases, plant pathogen control has been at least as good with compost teas as with conventional fungicides. However, research also suggests that different preparation methods and different composts may be required in order to optimise the qualities of the final product and the application method.

A review of this subject is made in the report written for Defra by A. Litterick *et al.* (2003) for Objective 4 of Defra project OF0313 and a full list of references is given there. This report is available from Defra and can be accessed through their website (www.Defra.gov.uk/farm/organic/default.htm).

Background and rationale for the project

Compost teas have been used in the USA as an alternative to fungicides on conventional and organic farms and nurseries for several years. They are being used to prevent and control foliar and soil-borne disease and to improve the health of soil and growing media. There are at least 15 companies making and selling compost tea brewers in the USA. Many of these brewers are aimed at gardeners and allotment holders, but some are made in larger sizes suitable for farmers and commercial horticulturists. The Compost Tea Industry Association (http://www.composttea.org), The Compost Tea Information and Research Foundation and the International Compost Tea Council (http://www.intlctc.org) have recently been formed in the USA. These organisations aim to provide unbiased information and aim to promote the safe, effective use of compost teas in farms and gardens.

Compost teas have been used on commercial horticultural holdings (on ornamentals) in The Netherlands for around 2 years. To our knowledge, all Dutch growers who use compost teas are buying kits including compost and compost tea brewers from Van Iersel, a company which advocates a production system known as "Microfarming".

Following reports of successful use of compost teas on nurseries in The Netherlands, around fifty UK ornamental growers are in the early stages of experimenting with compost teas on their nurseries. They are interested in finding out whether compost teas can improve crop growth and/or health and whether they can help reduce reliance on fungicides.

Most of the recent work relating to compost teas in the USA and The Netherlands has been carried out by commercial companies who are selling proprietary compost tea brewers and/or kits to make compost teas. Some of the advice which has been given to growers (particularly in the USA) has been inappropriate and based on few scientific facts. There is an urgent need for independent scientific work to:

- optimise production methods for compost teas
- optimise application strategies for compost teas
- assess the safety and minimise the risks to human health from the use of compost teas
- determine the factors affecting efficacy of compost teas in order to further develop strategies for maximising efficacy

If successful strategies for the production and use of compost teas are developed, there is potential to reduce fungicide costs, to maintain or improve crop growth and health and to improve soil health in field grown crops.

PROJECT AIM AND SPECIFIC OBJECTIVES

The overall aim of this project is:

to answer key questions relating to the preparation, application and effects of compost teas on UK ornamental nurseries and to give growers practical information to enable them to use compost teas to best effect following basic scientific work and glasshouse/tunnel trials.

The specific objectives are as follows:

Objective 1. Test the effect *(on crop growth, health and presence/absence of disease*) of teas made using four reputable compost tea brewers available on the world market on two ornamental species under experimental glasshouse conditions.

Objective 2. Determine the effect *(on crop growth, health and presence/absence of disease*) of compost type on the quality and effects of the finished tea on two ornamental species under experimental glasshouse conditions

Objective 3. Determine the effect *(on crop growth, health and presence/absence of disease*) of compost maturity on the quality and effects of the finished tea on two ornamental species under experimental glasshouse conditions

Objective 4a. Determine the effect of brew constituents on the effects of compost teas
Objective 4b. Determine the effect of additives on the effects of compost teas

Objective 5. Assess the characteristics (*pH, nutrient content, presence of beneficial organisms*) of compost teas used in trials carried out under Objectives 3 and 4.

Objective 6. Test teas made under the two best performing preparation systems (determined under objectives 1-4) on commercial nurseries. The effect of compost teas on the following will be determined:

- Crop growth and development (roots and shoots)
- Crop health (incidence/severity of diseases, presence of pests, pest damage and biological control agents)
- Soil/growing media health (based on respiration and hydrolytic enzyme activity)

Objective 7. Prepare a report based on work carried out in this study and an assessment of other important scientific work in the USA and Europe. The report will aim to:

- Briefly review releVant literature on compost teas since DEFRA project OF0313
- Summarise the results obtained in the project
- Provide guidance to growers on the preparation and use of compost teas
- Determine research priorities for the future

GENERAL MATERIALS AND METHODS

All trials contained four replicates and were laid out in randomised block designs. The growing media used was the same throughout the SAC-based trials and consisted of medium grade fibrous sphagnum peat mixed with dolomitic limestone (2.4 kg/m^3) and Osmocote Exact 15+9+9+3MgO+Te, 8-9 month at 3.5 kg/m^3 (Scotts).

Two species (lavender and choisya) were used throughout the SAC-based trials. The varieties used are named in individual trials. For each trial, a plot consisted of twenty plants of the same species placed in an individual plastic carrying tray lined with 5 cm of sand. The sand in each plot was watered as required in order to keep it damp (ie each tray was maintained as an individual sandbed). Pots were kept on individual sandbeds in order to prevent cross-contamination of neighbouring treatments.

Compost teas were prepared as far as possible according to the manufacturer's instructions for each brewer, ie
Xtractor (100 l) 46 g compost / l water + contents of Van Iersel kit as per instructions
Liquid Compost Brewer: (20 l) 24 g compost / l water + contents of Van Iersel kit as above
System 25 (80 l) 11 g compost / l water + contents of Van Iersel kit as above
Earth Tea Brewer (70 l) 13 g compost / l water + contents of Van Iersel kit as above

The brewers were filled with plain water and run for 3 hours prior to the addition of compost to remove chlorine from the water. Compost was then added (as above) and the brewers ran for 24 hours (18 hours for Trials 2, 3, 4a and 4b). Compost teas were filtered (0.4 mm mesh filter) prior to application.

Compost teas (or plain water control) were applied fortnightly in Trial 1, starting on the day of potting, as coarse overhead sprays (5 ml tea/m^2 water or 50 l/ha) diluted 1:5 in water. This was changed for Trials 2, 3, 4a and 4b, in which compost teas were applied as coarse overhead sprays undiluted to run-off. (NB. Application rates were changed for later trials following discussion with Steve Schueurell who achieved good disease control in scientific trials when using undiluted compost teas sprayed in this way).

Fungicides were applied fortnightly in the following programme:
Scotts Octave (46% w/w prochloraz, Scotts) applied at potting (2 g in 1 l water applied as a spray to run-off, equivalent to 220 l /ha)
Bavistin DF (50% w/w carbendazim, BASF) applied 2 weeks after potting (1 g in 1 l water applied as a spray to run-off, equivalent to 220 l /ha)
Aliette 80WG (80% w/w fosetyl aluminium, Aventis) applied 4 weeks after potting (5 g in 5 l water /m^2) as a drench
The above programme was repeated until trial harvest

The sprayer used was a Berthould Vermorel 2000 Pro (Berthould, F-69653 Villefranche-Sur-Saone Cedex, France) with a coarse fan nozzle.

NB. Trays were removed for treatments to avoid cross contamination of adjoining plots.

Analysis of variance (using Genstat) was carried out on results from all trials. Fischer's protected least significant difference tests were used to test for differences between paired treatment means.

TRIAL 1 - Effect of teas made using four brewers on ornamentals

Introduction

Almost all of the brewers being used in the UK are of a single model (The Xtractor) imported from The Netherlands from Compara by Fargro. The growers in this country seem generally happy with this model, but there have been no independent UK trials to compare performance of this brewer with performance of the other, more established models from the USA.

The aim of this trial was to test the effect (on crop growth, health and presence/absence of disease) of teas made using four different reputable compost tea brewers available on the world market on two ornamental species under experimental glasshouse conditions. The temperature of the finished teas was measured and microbial numbers were assessed to see whether there were differences between the teas produced by the different brewers. The Xtractor brewer (currently being used by UK ornamentals growers) was one of the four on test.

Materials and methods

Plant species were as follows:
Lavender [*Lavandula angustifolia* 'Imperial Gem']
Choisya [*Choisya ternata* 'Sundance']

Treatments were as follows:
- Tr. 1 plain water applied at same rates as compost teas
- Tr. 2 standard fungicide treatment [see General materials and methods]
- Tr. 3 tea applied with brewer 1 (Liquid Compost Brewer)
- Tr. 4 tea applied with brewer 2 (Xtractor)
- Tr. 5 tea applied with brewer 3 (System 25)
- Tr. 6 tea applied with brewer 4 (Earth tea brewer 22)

Brewers used were as follows:
Liquid Compost Brewer obtained from Compost Tea Brewers Ltd., 42a High Street, Theale, Reading, Berkshire, RG7 5AN, UK
Xtractor (Compara) Obtained from Fargro Ltd., Toddington Lane, Littlehampton, West Sussex, BN17 7PP, UK
System 25 Obtained from Growing Solutions Inc., Michael Alms, 160 Madison Street, Eugene, Oregon 97402, USA
Earth Tea Brewer obtained from EPM Inc., PO Box 1295 Cottage Grove Oregon 97424, USA.

Compost:
The compost used for Trial 1 was obtained from Van Iersel (through Fargro, Littlehampton, UK). The other ingredients sold by Van Iersel (through Fargro) along with the compost to form a kit (soil food ingredients, numbered 1 to 4) were included in every brew.

Method
- The trial was set up on Thursday 18 March 2004.
- 480 choisya and 480 lavender plugs were potted into 8 cm square pots. Individual trays were labelled with treatment and replicate numbers
- Trays were placed on the floor of a glasshouse (temperature range 15 - 25ºC) and treatments were applied as recorded in the General Materials and Methods. The trial was moved to a polythene tunnel on 12 May 2004 (temperature range 10 - 30ºC).
- Plants were checked for incidence of pests and diseases weekly. The only disease observed was botrytis (*Botrytis cinerea*) on lavender. Incidence and severity was quantified using a numerical scoring system as follows:
  0 = no botrytis
  1 = 1 - 10 basal leaves dead with visible botrytis. Sporulation present
  2 = > 10 basal leaves dead with visible botrytis as above
  3 = 1 stem dying or dead, with visible botrytis as above
  4 = 2 stems as above
  5 = 3 " " "
  6 = 4 " " "
  7 > 4 " " "
  8 = plant dead
- The only pest observed was red spider mite (*Tetranychus urticae*) on choisya. Incidence and severity was quantified using a numerical scoring system as follows:
  0 = no red spider mite

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1 = spider mite evident on lower leaves
2 = spider mite evident on lower leaves up to leaf tips, no leaf damage evident
3 = damage to leaf tips, some distortion
4 = as above, plus webbing evident on leaves
5 = as above, severe webbing, leaves discoloured

- Plant growth was assessed 7 and 18 weeks after the start of the trial by measuring plant height (mm) and/or the number of leaves or shoots. Leaf scorch was also assessed on choisya plants 18 weeks after potting.
- Destructive assessments (shoot dry weights) were made 18 weeks after the start of treatment.

Results

There were no significant differences between lavender shoot numbers, the clippings removed, the dry weights at harvest or the total dry weight of lavender plants in different treatments in Trial 1 (Table 1). There were no significant differences in the values of any parameter between the different replicates.

Table 1. Effect of compost tea brewed with four different brewers on the weight of lavender (*Lavandula angustifolia* 'Imperial Gem') plants (Trial 1).

		Weights (g)		
Treatment	**No. of shoots**	**Clippings dry weights**	**Shoot dry weights at harvest**	**Total shoot dry weight**
Plain water	132.3	30.7	84.1	114.8
Fungicide programme	131.6	32.6	88.4	121.0
Compost tea (Xtractor)	123.1	36.0	86.2	122.2
Compost tea (ETB)	159.9	35.7	88.5	124.2
Compost tea (System 25)	130.7	35.9	88.9	124.8
Compost tea (CTB)	123.1	32.5	80.7	113.2
Mean	133.3	33.9	86.1	120.0

Appropriate statistical analysis (ANOVA with transformations) showed that there were no significant differences between treatments

Botrytis (caused by *Botrytis cinerea*) was observed in lavender plants in all treatments in Trial 1 (Table 2). Botrytis gradually increased over the term of the trial. Botrytis was most severe on plants treated with compost tea made using the System 25 compost tea brewer. It was least severe on plants treated with plain water, however differences in botrytis disease severity were not significant. There were no significant differences in the values of any parameter between the different replicates. No pests were recorded on the lavender plants in Trial 1. Laboratory examinations of plants at harvest indicated that no diseases other than botrytis were present on the lavender plants.

There were no significant differences between choisya plant heights (recorded on either date), the number of shoots or the dry weights at harvest in different treatments in Trial 1 (Table 3). There were no significant differences in the values of any parameter between the different replicates.

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Table 2. Effect of compost tea brewed with four different brewers on development of botrytis on lavender (*Lavandula angustifolia* 'Imperial Gem') plants (Trial 1).

Treatment	Disease score (weeks after potting) (7)	(18)
Plain water	2.44	3.79
Fungicide programme	2.71	4.33
Compost tea (Xtractor)	2.19	3.80
Compost tea (ETB)	2.50	4.28
Compost tea (System 25)	2.89	5.34
Compost tea (CTB)	2.43	4.05
Mean	2.53	4.26

Appropriate statistical analysis (ANOVA with transformations) showed that there were no significant differences between treatments

Disease score: 0 = no botrytis; 1 = 1 - 10 basal leaves dead with visible botrytis, sporulation present; 2 = > 10 basal leaves dead with visible botrytis, sporulation present; 3 = 1 stem dying or dead, with visible botrytis, sporulation present; 4 = 2 stems dying or dead, with visible botrytis, sporulation present; 5 = 3 stems dying or dead, with visible botrytis, sporulation present; 6 = 4= stems dying or dead, with visible botrytis, sporulation present; 7 > 4 stems dying or dead, with visible botrytis, sporulation present; 7 = dead plant.

Table 3. Effect of compost tea brewed with four different brewers on the height, number of shoots and dry weight (tops) of choisya (*Choisya ternata* 'Sundance') plants (Trial 1).

Treatment	Plant height (mm) at 7 May	Plant height (mm) at 20 July	No. of shoots At 20 July	Dry weights at harvest (tops)
Plain water	120	184	3.3	66.8
Fungicide programme	117	186	3.3	60.2
Compost tea (Xtractor)	116	202	3.2	64.7
Compost tea (ETB)	117	184	3.3	63.2
Compost tea (System 25)	123	183	3.2	62.9
Compost tea (CTB)	116	193	3.4	65.5
Mean	118	189	3.3	63.9

Appropriate statistical analysis (ANOVA with transformations) showed that there were no significant differences between treatments

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Damage caused by red spider mite (*Tetranychus urticae*) was observed in choisya plants in all treatments in Trial 1 (Table 4). Red spider mite damage was most severe on plants treated with compost tea made using the Xtractor. It was least severe on plants treated with the fungicide programme, however differences in red spider mite damage were not significant. There were significant differences (P = 0.045) in the level of red spider mite damage between different replicates. There were no pests other than red spider mite present on the choisya plants and laboratory examinations of plants at harvest indicated that no diseases were present.

Table 4. Effect of compost tea brewed with four different brewers on the incidence and severity of damage caused by red spider mite (*Tetranychus urticae*) on (*Choisya ternata* 'Sundance') plants (Trial 1).

Treatment	**Damage caused by red spider mite (18 weeks after potting)**
Plain water	1.24
Fungicide programme	0.91
Compost tea (Xtractor)	2.76
Compost tea (ETB)	1.25
Compost tea (System 25)	2.06
Compost tea (CTB)	2.04
Mean	1.71

Scoring system as follows: 0=No red spider mite; 1=spider mite evident on lower leaves; 2=spider mite evident on lower leaves up to leaf tips, no leaf damage evident; 3=damage to tip leaves, some level of distortion; 4=as above, plus webbing evident on leaves; 5=as above, severe webbing, leaves discoloured

Appropriate statistical analysis (ANOVA with transformations) showed that there were no significant differences between treatments

Compost tea temperatures were measured immediately as brewing ceased. These varied from as low as 14ºC on a cool day in early spring to as high as 38ºC on a hot summer's day. It is worth noting that the brew temperatures of brews made in the Xtractor, Compost Brewer and System 25 were always within 2 to 3 ºC of one another. Brews made in the Earth Tea Brewer were always 6 to 8ºC warmer than those in the other brewers. This was probably because the motor in the Earth Tea Brewer is cooled by the compost tea itself during brewing. None of the other brewers are cooled by the tea during its production in this way.

Microbial numbers were measured in three of the brews made for Trial 1 (Table 5). The numbers of microorganisms counted in brews made from all four brewers were of a similar magnitude. Brews made using the Xtractor contained the highest numbers of microorganisms on average when counted in both nutrient and MacConkey agars. Brews made using the Compost Tea Brewer contained fewest microorganisms on average when counted in both nutrient and MacConkey agars. There were less than 100 CFU's *E. Coli* per ml in every brew tested. It was not possible to carry out statistical analysis on these results, since it would have been too costly and time-consuming to carry out the tests with sufficient replication to allow meaningful analysis.

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Table 5. Number of microorganisms in brews (Trial 1)

Brewer	Brew date	Mean colony forming units/ml*	
		Nutrient agar	**MacConkey agar**
Xtractor	14.04.04	1.10×10^8	2.20×10^7
	28.04.04	1.71×10^7	3.00×10^6
	28.05.04	2.56×10^7	3.00×10^6
	Mean	$\mathbf{5.09 \times 10^7}$	$\mathbf{9.30 \times 10^6}$
Earth Tea	14.04.04	6.00×10^7	1.80×10^7
	28.04.04	1.59×10^7	7.80×10^5
	28.05.04	2.99×10^7	2.24×10^6
	Mean	$\mathbf{3.53 \times 10^7}$	$\mathbf{8.67 \times 10^6}$
System 25	14.04.04	2.76×10^7	2.76×10^6
	28.04.04	1.13×10^7	1.72×10^6
	28.05.04	2.95×10^7	1.55×10^6
	Mean	$\mathbf{2.28 \times 10^7}$	$\mathbf{2.01 \times 10^6}$
CTB	14.04.04	2.13×10^7	1.68×10^6
	28.04.04	2.13×10^7	2.14×10^6
	28.05.04	1.52×10^7	4.10×10^5
	Mean	$\mathbf{1.93 \times 10^7}$	$\mathbf{1.41 \times 10^6}$

* Stated values were the means of two counts

This trial was allowed to continue for longer than originally intended in order to see whether differences emerged between treatments. The trial was finally harvested 18 weeks after it was set up.

Discussion

There were no significant differences between treatments for any of the parameters tested on either lavender or choisya plants in Trial 1. The plants grew well on the whole, although there was low but increasing levels of disease in the lavenders and red spider mite damage on the choisyas. Published work from the USA has indicated that use of compost teas can be associated with improved crop health and growth and reduced incidence and severity of disease. However, there are plenty of instances where compost extracts and teas have had no effects or even deleterious effects on plant growth and health (Litterick *et al.,* 2002; Scheuerell & Mahaffee, 2002). There were differences in the level of red spider mite damage between replicates. Replicates in the central part of the polythene tunnel suffered from greater damage. This may have been due to higher temperatures in that part of the tunnel.

Elaine Ingham of Soil Foodweb Inc. maintains that "poor quality" compost teas will have little or no effect on plant growth or health (Ingham, 2002). Quality in this sense refers to the numbers and diversity of beneficial microorganisms present. However, in this experiment, there is no reason to believe that the compost teas produced (or the compost teas used to produce them) were of poor quality. The numbers of total culturable bacteria (on nutrient agar) were within the range which is reported to be associated with disease suppression and varied between 1.13^7 to 1.10^8 CFU /ml (see discussion Trial 2 for further information). Van

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Iersel compost was used, two of the brewers (the Earth Tea Brewer and the System 25) have been shown to produce effective teas and the brewing methods were those recommended by the manufacturers. Good quality plants were used in standard growing media and growing conditions for the crop were as used in commercial nursery practice.

It has been suggested that compost teas should ideally be applied within a few hours of brewing, since microorganisms start to die shortly after brewing ceases (Ingham, pers. comm.). No published evidence of work of this type has been found. However the brews in Trial 1 were applied immediately after brewing, in late afternoon when the strength of the sun had decreased after midday. Elaine Ingham has said that compost teas should ideally be applied in the morning or evening (not during strong sun), since microorganisms tend to die more easily on the leaf in strong sunlight (Ingham, 2002). Again, we have not found published evidence of work to prove this, but followed her guidance, since it did make scientific sense.

In this trial, compost teas were prepared exactly according to the recipe devised by Van Iersel. The company assures us that this recipe has been tested and developed in order to optimise performance of the finished teas. Unfortunately, the results of this work have not been published and are not available for independent assessment (presumably due to an understandable wish for company confidentiality). However, it may be that the brewing additives used are adversely affecting performance of the teas in some way. Further tests may reveal whether this is the case.

In Trial 1, compost teas were applied as coarse overhead sprays (5 ml tea/m^2 water or 50 l/ha) diluted 1:5 in water. Discussion with Steve Scheuerell (a consultant to this project) confirmed that compost tea users in the USA often apply compost teas at this rate, diluted in sufficient water to cover the crop. However his own experience using compost teas to successfully control disease involved spraying undiluted teas to run-off. Future trials will use compost teas in this way, since this practice will ensure maximum coverage of leaves and may provide the best possible chance of seeing differences between treatments.

TRIAL 2 - Effect of compost type on the efficacy of compost tea

Introduction

Growers in the UK are almost exclusively using a compost purchased from van Iersel in the Netherlands (via the UK company Fargro). This compost is based on greenwaste. It contains no animal manures and is imported in small quantities at very high cost (in comparison to the cost of similar composts produced in the UK). Such reliance on a single brand of compost is not ideal since growers would be left with no alternative should van Iersel go out of business or should they choose to increase compost price.

The aim of this trial is to determine the effect (on crop growth, health and presence/absence of disease) of compost type on the quality and effects of the finished tea on two ornamental species under experimental glasshouse conditions. The van Iersel compost (currently being used by UK ornamentals growers) was one of the four on test.

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Materials and methods

Plant species were as follows:
Lavender [*Lavandula angustifolia* 'Hidcote']
Choisya [*Choisya ternata* 'Sundance']

Treatments were as follows:
- Tr. 1 plain water applied at same rate as compost teas
- Tr. 2 standard fungicide treatment [see General materials and methods]
- Tr. 3 tea made from compost (CMC compost i., Van Iersel)
- Tr. 4 tea made from compost (CMC compost ii.)
- Tr. 5 tea made from compost (greenwaste compost I)
- Tr. 6 tea made from compost (greenwaste compost II)

NB: Van Iersel compost (Treatment 3) is made by the patented Controlled Microbial Composting (or CMC) process. Several UK farming companies make compost using the same process. The compost in Treatment 4 was obtained from an organic farm in Scotland and was made from a mixture of strawy cattle manure, greenwaste and grass clippings. The compost in Treatments 5 and 6 were made outdoors in turned windrow systems similar to those used to produce CMC compost. They were taken from separate UK composting facilities (both of which were accredited with the UK Composting Association as compliant with BSI PAS100) and were made solely from greenwaste similar to that used (as far as can be ascertained) by Van Iersel to make their compost.

Brewers used
No differences were observed between the performance of compost teas made using different brewers in Trial 1. The Xtractor was therefore chosen to produce tea for Trial 2, since it is the one used by most UK growers.

Method
- The trial was set up on Tuesday 22 June 2004.
- 480 choisya and 480 lavender plugs were potted into 8 cm square pots. Individual trays were labelled with treatment and replicate numbers
- Trays were placed on the floor of a polythene tunnel (temperature range 10 - 30ºC) and treatments were applied as recorded in the 'General Materials and Methods'
- Fungicides were applied as in commercial practice to plants in Treatment 2 (See 'General Materials and Methods').
- Plants were checked for incidence of pests and diseases weekly. If present, the severity of pest or disease attack was quantified using a numerical scoring system as shown for Trial 1.
- Plant growth was assessed 12 weeks after the start of the trial by measuring plant height (mm) and the number of terminal shoots (Choisya). Lavenders were assessed for quality and shoot numbers. The quality scoring system for lavenders was as follows:
  0 = dead plant
  1 = plant unsaleable due to small size and/or, presence of brown shoots
  2 = plant badly distorted in shape with some brown areas
  3 = plant has no brown areas, but shape uneven
  4 = plant has no brown areas, but size or shape not of top quality
  5 = robust healthy plant of good size
- Destructive assessments (shoot dry weights) were made 12 weeks after the start of treatment.

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Results

Statistical analysis (ANOVA with transformations) showed that there were significant differences between quality scores of treatments (P = 0.045, Table 6). Lavender plants treated with fungicides had higher quality scores than those treated with plain water or compost tea made from the Van Iersel compost.

Statistical analysis (ANOVA with transformations) showed that there were significant differences between the number of flower spikes in different treatments (P = 0.039). Lavender plants treated with compost tea made from the Van Iersel compost or greenwaste compost ii. had fewer flower spikes than those treated with fungicides or greenwaste compost i.

Statistical analysis (ANOVA with transformations) showed that there were significant differences between the shoot dry weight of plants at harvest (P = 0.017). Lavender plants treated with fungicides or compost tea made from CMC compost ii. had higher shoot dry weights than those treated with plain water or compost tea made from the Van Iersel compost.

There were no significant differences between the number of shoots on plants in different treatments and no significant differences in the values of any parameter between the different replicates.

Table 6. Effect of compost tea brewed from four different composts on the weight of lavender (*Lavandula angustifolia* 'Imperial Gem') plants (Trial 2).

Treatment	**No. of shoots**	**No. of flower spikes**	**Quality score**	**Shoot dry weights at harvest (g)**
1 Plain water	81	3.2^{ab}	3.3^{a}	83^{a}
2 Fungicide programme	82	4.2^{b}	4.0^{b}	96^{b}
3 Compost tea (CMC Van Iersel)	77	2.7^{a}	3.2^{a}	83^{a}
4 Compost tea (CMC II)	88	3.3^{ab}	3.7^{ab}	93^{b}
5 Compost tea (greenwaste I)	79	3.9^{b}	3.6^{ab}	91^{ab}
6 Compost tea (greenwaste II)	80	2.7^{a}	3.8^{ab}	84^{ab}
Mean	81.2	3.3	3.6	88
LSD (level of significance)	10.27	1.06	0.54	8.3
	NS*	(P = 0.039)	(P = 0.045)	(P = 0.017)

Different superscript letters indicate differences at the significance level shown.
NS* = not significant

Quality scoring system as follows: 0 = dead plant; 1 = plant unsaleable due to small size and/or, presence of brown shoots; 2 = plant badly distorted in shape with some brown areas; 3 = plant has no brown areas, but shape uneven; 4 = plant has no brown areas, but size or shape not of top quality; 5 = robust healthy plant of good size

Botrytis (caused by *Botrytis cinerea*) was observed in lavender plants in all treatments in Trial 2 (Table 7). Botrytis gradually increased over the term of the trial. It was most severe on plants treated with plain water or compost tea made using greenwaste compost i and least severe on plants treated with fungicide, however differences in botrytis disease severity were not significant. There were no significant differences in the values of any parameter between

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Table 7. Effect of compost tea brewed from four different composts on development of botrytis on lavender (*Lavandula angustifolia* 'Imperial Gem') plants (Trial 2).

Treatment	Disease score
1 Plain water	3.1
2 Fungicide programme	2.3
3 Compost tea (CMC Van Iersel)	3.0
4 Compost tea (CMC II)	3.0
5 Compost tea (greenwaste I)	3.1
6 Compost tea (greenwaste II)	2.3
Mean	2.8

Appropriate statistical analysis (ANOVA with transformations) showed that there were no significant differences between treatments.

Disease score: 0 = no botrytis; 1 = 1 - 10 basal leaves dead with visible botrytis, sporulation present; 2 = > 10 basal dead with visible botrytis, sporulation present; 3 = 1 stem dying or dead, with visible botrytis, sporulation present; 4 = 2 stems dying or dead, with visible botrytis, sporulation present; 5 = 3 stems dying or dead, with visible botrytis, sporulation present; 6 = 4= stems dying or dead, with visible botrytis, sporulation present; 7 > 4 stems dying or dead, with visible botrytis, sporulation present; 7 = dead plant.

the different replicates. No pests were recorded on the lavender plants in Trial 1. Laboratory examinations of plants at harvest indicated that no diseases other than botrytis were present on the lavender plants.

There were no significant differences between choisya plant heights (recorded on either date), number of shoots or shoot dry weights at harvest in different treatments in Trial 2 (Table 8). There were no significant differences in the values of any parameter between the different replicates.

Damage caused by red spider mite (*Tetranychus urticae*) was observed in choisya plants in all treatments in Trial 2 (Table 9). Red spider mite damage was most severe on plants treated with compost tea made using CMC compost ii and least severe on plants treated with greenwaste compost ii, however differences in red spider mite damage were not significant. There were no significant differences in the level of red spider mite damage recorded in different replicates. There were no pests other than red spider mite present on the choisya plants and laboratory examinations of plants at harvest indicated that no diseases were present.

Microbial numbers were measured in two of the brews made for Trial 2 (Table 10). The numbers of microorganisms counted in brews made from all four brewers were of a similar magnitude. Brews made using Van Iersel compost contained the highest and CMC compost ii the lowest numbers of microorganisms on average when counted in nutrient agar. Brews made with Greenwaste compost I contained the highest and CMC compost ii the lowest numbers of microorganisms on average when counted in MacConkey agar. There were less than 1000 CFU's *E. Coli* per ml in every brew tested. It was not possible to carry out statistical analysis on these results, since it would have been too costly and time-consuming to carry out the tests with sufficient replication to allow meaningful analysis.

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Table 8. Effect of compost tea brewed from four different composts on height, number of terminal shoots and shoot dry weight of choisya (*Choisya ternata* 'Sundance') plants 12 weeks after potting (Trial 2).

Treatment	Plant height (mm)	No. of terminal shoots	Shoot dry weights (g)
1 Plain water	175	4.4	47
2 Fungicide programme	174	6.0	51
3 Compost tea (CMC Van Iersel)	154	6.7	43
4 Compost tea (CMC II)	172	5.7	46
5 Compost tea (greenwaste I)	158	6.3	45
6 Compost tea (greenwaste II)	177	5.2	49
Mean	168	5.7	47

Appropriate statistical analysis (ANOVA with transformations) showed that there were no significant differences between treatments

Table 9. Effect of compost tea brewed from four different composts on the incidence and severity of damage caused by red spider mite (*Tetranychus urticae*) on (*Choisya ternata* 'Sundance') plants (Trial 2).

Treatment	Damage caused by red spider mite 12 weeks after potting)
1 Plain water	1.2
2 Fungicide programme	1.3
3 Compost tea (CMC Van Iersel)	2.0
4 Compost tea (CMC II)	2.2
5 Compost tea (greenwaste I)	2.0
6 Compost tea (greenwaste II)	1.0
Mean	1.6

Damage scoring system as follows: 0=No red spider mite; 1=spider mite evident on lower leaves; 2=spider mite evident on lower leaves up to leaf tips, no leaf damage evident; 3=damage to tip leaves, some level of distortion; 4=as above, plus webbing evident on leaves; 5=as above, severe webbing, leaves discoloured

Appropriate statistical analysis (ANOVA with transformations) showed that there were no significant differences between treatments

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Table 10. Number of microorganisms in brews (Trial 2)

		Colony forming units/ml	
Compost	**Brew date**	**Nutrient agar**	**MacConkey agar**
CMC Van Iersel	21.07.04	7.10×10^{8}	2.40×10^{6}
	05.08.04	1.00×10^{8}	1.71×10^{7}
	Mean	**4.05×10^{8}**	**9.75×10^{6}**
CMC ii	21.07.04	6.10×10^{6}	1.60×10^{6}
	05.08.04	1.82×10^{7}	1.40×10^{6}
	Mean	**1.23×10^{7}**	**1.50×10^{6}**
Greenwaste I	21.07.04	1.44×10^{7}	1.07×10^{7}
	05.08.04	2.20×10^{8}	4.00×10^{7}
	Mean	**1.17×10^{8}**	**2.54×10^{7}**
Greenwaste ii	21.07.04	1.90×10^{7}	3.70×10^{6}
	05.08.04	4.90×10^{8}	2.50×10^{6}
	Mean	**2.55×10^{8}**	**3.10×10^{6}**

Discussion

Lavender plants treated with fungicides had significantly higher quality scores than those treated with plain water or compost tea made from the Van Iersel compost. Lavender plants treated with compost tea made from the Van Iersel compost or greenwaste compost ii. had significantly fewer flower spikes than those treated with fungicides or greenwaste compost i. Finally, lavender plants treated with fungicides or compost tea made from CMC compost ii. had higher dry weights than those treated with plain water or compost tea made from the Van Iersel compost. Although the lavenders in Trial 2 were infected with botrytis, there were no significant differences between treatments. There were no significant differences between treatments for any of the parameters measured on choisya plants.

The protocols being used in Trial 2 were based on best practice for compost teas which has been developed in the USA. Some of this best practice is based on published research, whereas some information is currently coming from consultants reports on websites and through personal communication. Again (as with Trial 1), the plants, growing media and composts used to make teas were of best available quality and were stored in cool dark conditions prior to use. The crop husbandry was managed and compost tea applications were made by an experienced horticultural technician. The staff of this project can think of nothing to indicate that anything they might have done may have affected the way in which the teas performed.

In addition to published work which has demonstrated beneficial effects of compost teas, several key UK growers and consultants continue to be convinced of the value of compost teas in improving crop health and growth. Their experience is based on observations rather than on results of replicated trials, but there is no reason to doubt their convictions. It is recognised that disease pressure is often higher on nurseries where large areas of single crops

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are grown and differences in disease pressure may influence the effects which compost teas have.

Microbial populations in compost tea are thought to be the most significant factor contributing to disease suppression. However, there is very little published information available on the microbial species composition of compost tea and how these organisms survive on plants surfaces (Scheuerell and Mahaffee, 2002). This lack of understanding likely contributes to the variable efficacy often reported for controlling plant pathogens with compost teas. Standard methods for reporting compost tea microbial populations have not been established and this further adds to the confusion, since comparisons across experimental systems are not possible. The numbers of total culturable bacteria reported from disease suppressive compost tea (NCT) vary with a range of 10^7 to 10^{10} CFU per ml. Microbial counts made from brews in Trials 1 and 2 indicate that bacterial numbers were usually within that range. However, variable disease suppression has been reported even where brews (NCT and ACT) are known to contain between 10^9 to 10^{10} CFU per ml. (Scheuerell, unpublished data).

Variability in bacterial species might be a cause of variable efficacy in disease control when using teas, but more work is required if a relationship is to be established between populations of specific microorganisms and disease control or improved plant growth/health. Work is also required to determine how to produce composts with a suitable balance of microbial species to produce reliably effective compost teas.

TRIAL 3 - Effect of compost maturity on the efficacy of compost tea

Introduction
Indications from work on composts have suggested that their disease suppressive effects are dependent on their maturity (Litterick *et al.*, 2003; Nelson *et al.*, 1983). Since it is recognised that the microflora of compost teas is dependent on that within the compost from which they are made, the maturity of composts used to make compost tea may be important. This trial therefore aimed to determine the effect (on crop growth, health and presence/absence of disease) of compost maturity on the quality and effects of the finished tea on two ornamental species under experimental glasshouse conditions.

Materials and methods

Plant species were as follows:
Lavender [*Lavandula angustifolia* 'Hidcote']
Choisya [*Choisya ternata* 'Sundance']

Treatments were as follows:
- Tr. 1 plain water applied at brewer rates
- Tr. 2 standard fungicide treatment [see General materials and methods]
- Tr. 3 tea made from compost 1 (CMC compost i., Van Iersel)
- Tr. 4 tea made from compost 2 (greenwaste, immature)
- Tr. 5 tea made from compost 3 (greenwaste, mature)
- Tr. 6 tea made from compost 4 (greenwaste, very mature)

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NB: Composts 2, 3 and 4 were taken from a commercial greenwaste compost production facility in the UK. The immature compost was taken from a 10 week old windrow. The mature compost was taken from a windrow which was 3 months old and the very mature compost was taken from a windrow which was 2 years old. The same composts were used throughout the trial and were stored at 10-15ºC in a dark room during the period of the trial. Compost stability/maturity was confirmed by testing for carbon dioxide evolution using the method developed by ADAS Direct labs (WRAP, 2003). The results were as follows:

Compost	CO_2 Evolution value	Indication
1 (CMC compost i., Van Iersel)	3.1	Mature compost
2 (greenwaste, immature)	11.3	Immature compost
3 (greenwaste, mature)	5.8	Mature compost
4 (greenwaste, very mature)	2.8	Very mature compost

Brewers used
Since no differences were observed between the performance of compost teas made using different brewers in Trial 1, two brewers were used in Trial 3 (the Xtractor and the System 25). The Xtractor was used to produce tea for Treatment 3 on potting day and Treatment 4 on the following day. The System 25 was used to produce tea for Treatment 5 on potting day and Treatment 6 on the following day. The same procedure was repeated each fortnight, although the brewers were alternated for the treatments each fortnight (eg the Xtractor was used to prepare Treatments 5 and 6 on the second treatment date).

Method
- The trial was set up on Tuesday 21 September 2004.
- 480 choisya and 480 lavender plugs were potted into 8 cm square pots
- 20 plants of the same species were placed in individual plastic carrier trays lined with 5 cm of sand (to simulate individual sandbeds). One tray of each made up a plot.
- Each tray was labelled with treatment and replicate numbers
- The trays were placed in a randomised block design on the floor of a polyethene tunnel (temperature range 10 - 30ºC)
- Compost teas (or plain water control) were applied fortnightly starting on the day of potting, as coarse overhead sprays undiluted to run-off. NB. Trays were removed for treatments to avoid cross contamination of adjoining treatments.
- Fungicides were applied as in commercial practice to plants in Treatment 2
- Plants were checked for incidence of pests and diseases weekly. If present, the severity of pest or disease attack was quantified using a numerical scoring system.
- Plant growth will be assessed 2 and 4 months after the start of the trial by measuring plant height (mm) and the number of leaves or shoots.
- Destructive assessments (shoot dry weights) will be made 4 months after the start of treatment.

Current situation
The trial has been under observation since it was set up. No differences have been recorded between treatments and there is no evidence of any disease or pest damage. The decision has been made to keep the trial going until spring 2005 in order to determine whether differences will arise between different treatments.

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TRIALS 4a and 4b - Effect of pre and post brewing additives on the performance of compost teas

Introduction

Evidence from the USA has shown that additives put in both prior to and after brewing can have a significant effect on the performance of the finished tea. The components of the Van Iersel kit (supplied with their compost and used by UK ornamentals growers) may have been tested individually to confirm their effects/usefulness, but if so, the results have not been published and are not available for independent appraisal. It is important that the formulation of brews (both pre and post-brewing) is tested under UK growing conditions in order to ensure that compost teas are used to best effect.

The aim of trials under Objective 4 was to determine the effect of brew constituents on the performance of compost teas and also to determine the effect of post-brewing additives on the performance of compost teas.

Materials and methods

Plant species were as follows:
Lavender [*Lavandula angustifolia* 'Hidcote']
Choisya [*Choisya ternata* 'Sundance']

Treatments in Trial 4a were as follows:

- Tr. 1 plain water applied at brewer rates
- Tr. 2 standard fungicide treatment [see General materials and methods]
- Tr. 3 Van Iersel Kit mixture (Van Iersel compost + herbs + sugars + nutrients)
- Tr. 4 Van Iersel compost + herb mix + sugars + nutrients (see below for details)
- Tr. 5 CMC compost + herb mix + sugars + nutrients (as above)
- Tr. 6 CMC compost + sugars + nutrients (as above, no herbs)

Treatment details (trial 4a)
Additives added in treatments 4, 5 and 6 included: molasses, biohumates (Biotechnica, Reading, UK), seaweed extracts (Maxicrop, Corby, UK) and a herb mixture (containing chamomile (*Matricaria chamomilla*), dandelion (*Taraxacum officinalis*), stinging nettle (*Urtica dioica*), valerian (*Valeriana officinalis*), yarrow (*Achillea millefolium*) and oak bark (*Quercus robur*). All additives were mixed into brews at the same rate as their equivalents in the Van Iersel kits. See "Current situation" section for reasons as to why these additives were chosen.

Treatments in Trial 4b will be as follows:

- Tr. 1 plain water applied at brewer rates
- Tr. 2 standard fungicide treatment
- Tr. 3 tea applied with Codacide oil (95 % vegetable oil, Microcide)
- Tr. 4 tea applied with Cutonic foliar booster (100 % w/w p-p-copolymer, Lambson)
- Tr. 5 tea applied with methyl cellulose
- Tr. 6 CMC tea applied with casein

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Brewers used

Since no differences were observed between the performance of compost teas made using different brewers in Trial 1, two brewers were used in Trial 4 (the Xtractor and the System 25). The Xtractor was used to produce tea for Treatment 3 on potting day and Treatment 4 on the following day. The System 25 was used to produce tea for Treatment 5 on potting day and Treatment 6 on the following day. The same procedure was repeated each fortnight, although the brewers were alternated for the treatments each fortnight (eg the Xtractor was used to prepare Treatments 5 and 6 on the second treatment date).

Method

- Trial 4a was set up on 18 October 2004. Trial 4b will be set up in early spring 2005.
- 480 choisya and 480 lavender plugs were potted into 8 cm square pots. Individual trays were labelled with treatment and replicate numbers.
- Trays were placed on the floor of a glasshouse (temperature range 15 - 25°C) and treatments were applied as recorded in the general materials and methods.
- Plants were checked for incidence of pests and diseases weekly. If present, the severity of pest or disease attack was quantified using a numerical scoring system. (Note the system).
- Plant growth was assessed 2 and 4 months after the start of the trial by measuring plant height (mm) and the number of leaves or shoots.
- Destructive assessments (shoot dry weights) were made 4 months after the start of treatment.

Current situation

The trial has been under observation since it was set up. No differences have been recorded between treatments and there is no evidence of any disease or pest damage. The decision has been made to keep the trial going until spring 2005 in order to determine whether differences will arise between different treatments. The decision to delay harvest of Trial 3 (in order to see whether treatment differences occur) has meant that the start date of Trial 4b also has to be delayed (since there are not enough brewers to run three experiments at the same time.

It has not proved possible to determine the exact nature of the additives which Van Iersel sell as "essential" constituents of their compost tea kits. This is presumably due to commercial confidentiality. However, study of a range of information sources on compost tea production and biodynamic farming (Diver 1998, 2001; Ingham, 2002; Koepf, 1989) have led us to be fairly certain that the four additives sold by Van Iersel include sugars, nutrients (humates and seaweed extracts) and herbs.

Many compost tea recipes from the USA include sugars (in the form of molasses). Some include humates and/or seaweed extract. The addition of herbs is much less common in standard compost tea recipes from the USA. However, five herbs plus oak bark are used to make the biodynamic "compost and manure preparations" which are used to improve the composting process and the plants to which they are applied in biodynamic farming systems (Koepf, 1989). The five herbs used are chamomile (*Matricaria chamomilla*), dandelion (*Taraxacum officinalis*), stinging nettle (*Urtica dioica*), valerian (*Valeriana officinalis*) and yarrow (*Achillea millefolium*). The compost produced by Van Iersel is understood to be produced according to the CMC method, which was devised by a biodynamic farming family, therefore it was thought that the herbs used by Van Iersel might be those used in biodynamic preparation 501. This looks likely, since flower parts from chamomile and yarrow were identified within the herb mix supplied by van Iersel.

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OBJECTIVE 5 - Assess the characteristics of compost teas used in trials

Introduction

There is very little scientific information available on the biological and chemical characteristics of compost teas. It is currently possible to send samples of compost teas off to the Soil Foodweb Labs in the USA or in The Netherlands for microbiological testing. However, this involves significant delays (due to postage/courier times) between producing and testing the teas. In addition, due to the commercial nature of the laboratories involved, there is very little published information available on the biological and chemical characteristics of compost teas made using different composts, brewers, brew constituents and techniques.

There is a need to gather information about the chemical and biological characteristics of compost teas in an effort to determine the characteristics of "good" teas and "bad" teas. This information may help us develop methods for making reliably effective compost teas.
Work under objective 5 aims to assess the characteristics (*pH, nutrient content, presence of beneficial organisms*) of compost teas used in trials carried out under Objectives 3 and 4.

Materials and methods

Samples were stored at 4°C immediately upon arrival from SAC, and stored for up to 3 weeks prior to analysis. Serial dilutions were prepared in sterile distilled water and the number of total viable bacteria was estimated using the pour plate technique and Nutrient Agar. This is a non-selective growth medium for bacteria which is suitable for comparative purposes.

Additional tests were carried out to estimate the number of coliform bacteria and *Escherichia coli* using MacConkey Agar. This is a differential medium for the detection, isolation and enumeration of coliforms and intestinal pathogens in water, dairy products and biological specimens. Serial dilutions and the pour plate technique were used for this method.

Current situation

This work is on-going. Results to date are presented in the results sections of trials 1 and 2.

Discussion of results to date

A specific microbiological concern about compost tea production practices that use additives to increase microbial populations is that they may also support growth of bacterial human pathogens from undetectable to easily detectable numbers thereby potentially posing a risk of contaminating crop plants with human pathogens.

However, the evidence of dangers from pathogens is inconsistent. There have been no reported cases of food borne illness from the use of compost tea but, on the other hand, there have been no epidemiological health/microbial studies done to evaluate this effect. For compost tea, averting the theoretical possibility of contaminating crops with human pathogens can be approached by:

(a) implementing measures that reduce the potential for pathogens to enter compost tea production systems, and

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(b) performing quality assurance tests to demonstrate that specific compost tea production systems produce compost tea that meets microbiological quality guidelines.

In general, pathogens that enter the composting process in feedstocks might come out at the same, lower, or higher levels. Processes or materials that have a high probability of increasing human pathogens during compost tea production are of greatest concern. Feedstocks such as manure have a high probability of containing pathogenic organisms. These types of materials can be processed to reduce populations of indicator microbes and pathogens to acceptable levels by following the requirements of PAS 100 (BSI,2002).

Compost stability affects the ability of *Salmonella* spp. to re-colonise composted materials (Milner *et al*, 1987) but data are lacking on the relationship between human pathogen growth potential in compost tea and compost stability. Re-growth of human pathogens in compost tea appears to be dependent on the concentration of compost tea additive used. In addition, the significant interaction between compost source and additives on the re-growth potential of human pathogens indicates a need to test individual batches of compost with defined concentrations of compost tea.

The recent US National Organic Standards Board Compost Tea Task Force Report (NOSB, 2004) proposed that compost tea made **without compost tea additives** could be applied without restriction. Compost tea made **with compost tea additives** could be applied without restriction if the compost tea production system (same compost batch, additives, and equipment) has been pre-tested to produce compost tea that meets the recommended recreational water quality guidelines for a bacterial indicator of fecal contamination (*Escherichia coli* or enterococcI). It was further proposed that if compost tea made with compost tea additives has not been pre-tested for indicator bacteria, its use on food crops should be restricted to the 90/120 day pre-harvest interval. Crops not intended for human consumption, such as ornamental plants should be exempt from bacterial testing and 90/120 day pre-harvest interval restrictions.

Our results are encouraging in that they show that the populations of the indicator coliform bacteria are <1000 cfu ml^{-1}, a value which falls within the acceptable range of values recommended in PAS 100.

TRIAL 6 - Nursery-based trials to determine the effects of compost teas

Introduction

The aim of this project as a whole is to develop methods for using compost teas which can be easily used on commercial nurseries. For this reason, the methods developed under Objectives 1 to 4 will be tested on nurseries throughout the UK. The original intention was to carry out trials on four nurseries. Trials have been started on five nurseries and a sixth is interested in carrying out a small trial. The intention is to assess the use of compost teas as part of an integrated pest and disease control programme on commercial nurseries. For this reason, the impact of teas on existing IPM programmes will be assessed during the summer of 2005.

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Materials and methods

Five trials have been set up to date at different nurseries including: Hewton Nurseries, West-end Nurseries, Aline Fairweather, Notcutts Nurseries and Fyne Plants (For full addresses see Trial 6, Current situation). Indications are that a further grower is keen to set up a second trial on heathers in 2005. There are three treatments and four replicates in each trial, with twenty plants of each species per plot. Some of these trials involve lavender and choisya in order to provide continuity from the first four trials. However, some growers have included additional crops which are important to their businesses.

Plant species were as follows:
Choisya [*Choisya ternata* 'Aztec pearl'] Hewton Nursery
Cordyline [*Cordyline australis*] Hewton Nursery
Cordyline [*Cordyline australis* 'Red star'] West End Nurseries
County rose [*Rosa* 'Oxfordshire'] Notcutts Nurseries
Heather [*Calluna vulgaris*] Fyne Plants
Lavender Lavender [*Lavandula angustifolia* 'Willowbridge Calico'] West End nurseries
Lavender Lavender [*Lavandula angustifolia* 'Hidcote'] Aline Fairweather
Phygelius [*Phygelius* 'Orange Fanfare'] Aline Fairweather

Treatments are as follows:
- Tr. 1 Plain water applied at same rates as compost teas
- Tr. 2 Compost tea applied at 5 ml/m^2 (ie 50 l/ha). This may be diluted in water in order to allow application through overhead irrigation equipment, but the tea is still applied at the same rate. Tea will be made according to the methods noted below.
- Tr. 3 Standard fungicide treatment [as normally or formerly applied on the nursery]

Methods
- Growing media was mixed as normal for each nursery and plugs/liners were potted on into the pots to be used during the trial (ie 240 plants of each of choisya and lavender or other).
- Twenty plants of the same species were placed in each carrying tray. One tray of each made up a plot. Trays are not essential, they simply make it easier to remove the plants for treatment.
- Each tray was labelled clearly (indelible pen) with the treatment and replicate
- The trays were placed in the specified randomised block design on the floor of the glasshouse
- Each trial block of species was surrounded with other plants of the same species to minimise edge effects.
- Compost teas were prepared using the Van Iersel Xtractor and were applied fortnightly (or plain water control for Treatment 1) starting on the day of potting, as coarse overhead sprays applied at 5 ml/m^2 (ie 50 l/ha). The tea can be diluted in water in order to allow application through overhead irrigation equipment, but the tea must still go on at the same rate.
- Compost tea treatments may be omitted during the months of December, January and February if growing media is becoming too wet. However, exact records MUST be kept as to the dates when Treatments 1 to 3 are applied.
- Trays were removed and treated in a different area in order to apply treatments. They were replaced in the randomised block design after treatment. This is to avoid cross contamination of adjoining treatments.
- Fungicides were applied according to normal commercial practice to plants in Treatment 3 (details of rates and application dates were kept for each nursery).

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Assessments

- Plant growth and health were assessed 3, 6, 9 and 12 months after the start of the trial by:
    - Measuring plant height (mm)
    - Recording the number of breaks or shoots as appropriate at the time of assessment
- Destructive assessments (shoot fresh and dry weights) were made 12 months after the start of treatment. The shoots of each plant must be weighed twice (once fresh, once after drying for 48 hours at 70ºC) and recorded.
- Plants were checked weekly for incidence of pests and diseases. If pests/diseases were present, the severity of the pest or disease attack should be quantified using a numerical scoring system. (The exact nature of this will be chosen depending on the type of pest or disease present).

Current situation on nurseries

Hewton Nurseries The trial was set up on 20 August 2004. Compost teas have been applied fortnightly, four times. No assessments have been made yet. Proposed date for first assessment: early December 2004.

West-End Nurseries The trial was set up on 19 August 2004. Compost teas have been applied fortnightly, four times. No assessments have been made yet. Proposed date for first assessment: early December 2004.

Aline Fairweather The trial was set up on 24 August 2004. Compost teas have been applied fortnightly, four times. No assessments have been made yet. Proposed date for first assessment: early December 2004.

Notcutts Nurseries The trial was set up on 12 October 2004. Compost teas have been applied once to date according to the trial protocol. No assessments have been made yet. Proposed date for first assessment: January 2005.

Fyne Plants The trial was set up on 9 July 2004. The grower was initially very keen to run the trial, but felt he had to abandon it due to pressures of work later in the season. He has no plans to set up a further trial this year, but may agree to set up a trial in 2005. No assessments were made prior to the trial being abandoned.

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Conclusions and future work

- Results from Trial 1 showed that there were no differences between the growth of either lavender or choisya plants treated with fungicides, plain water or compost teas made using four different brewers.
- Results from Trial 1 showed that there were no differences in the amount of disease caused by botrytis on either lavender or choisya plants treated with fungicides, plain water or compost teas made using four different brewers.
- Results from Trial 2 showed that lavender plants treated with fungicides had significantly higher quality scores than those treated with plain water or compost tea made from the Van Iersel compost.
- Results from Trial 2 showed that lavender plants treated with compost tea made from the Van Iersel compost or greenwaste compost ii. had significantly fewer flower spikes than those treated with fungicides or greenwaste compost i.
- Results from Trial 2 showed that lavender plants treated with fungicides or compost tea made from CMC compost ii. had higher dry weights than those treated with plain water or compost tea made from the Van Iersel compost.
- Although the lavenders in Trial 2 were infected with botrytis, there were no significant differences between treatments.
- Results from Trial 2 showed that there were no significant differences between treatments for any of the parameters measured on choisya plants.
- Plate counts showed that the numbers of total culturable bacteria recorded from brews in Trials 1 and 2 were usually within the range reported for disease suppressive compost teas (ie they were between 10^7 to 10^{10} CFU per ml).

- Staff who carried out work during Trials 1 and 2 can find no reason to suggest that inappropriate protocols were devised for the work. There is published evidence to show that compost teas can in some cases improve crop growth and health and can reduce incidence and severity of disease in some situations. However, there is also published evidence to show that compost teas can have no effects, variable effects or even deleterious effects on plant growth or health. The results of Trials 1 and 2 were not therefore without precedent.

- Trials 3 and 4a are in progress at SAC. No differences are being observed between treatments at this stage. These trials will be allowed to run until early spring in order to determine whether differences can be detected between treatments.
- Trial 4b will be set up as soon as Trial 3 is complete.

- Nursery trials (Trial 6) are now running up on four UK sites. The first assessments are due in the near future.

- If positive effects of compost teas on plant growth or health are detected in any of the trials within this or related projects, microbial analysis of the effective tea will be carried out to determine whether differences exist between it and previously analysed teas which have had no effect.

- The progress of this project and the trials within it will continue to be compared with current work on compost teas in other countries, especially the USA. Useful information will be incorporated into trial protocols in an effort to improve the effects of compost teas used in experimental work.

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TECHNOLOGY TRANSFER

There has been a strong interest in compost teas in the UK during 2004, not only in ornamental horticulture, but also in the waste management and compost production industries and in organic agriculture/horticulture. Audrey Litterick has been asked to speak at several seminars and conferences as shown below. In each case, compost teas were defined, the results of published work was discussed and the problems and potential of compost teas outlined. This HDC-funded project was introduced and its aims outlined, but no results were presented at any of the seminars, since the audiences were in general not HDC members.

Litterick, A.M. (2004) "Compost Teas - a simple disease control solution". Delivered at a one day seminar entitled "Emerging technologies - composting and using compost". Organised by Imperial College London and Enviros Consulting Ltd., Southwark Cathedral, London on 3 November 2004.

Litterick, A.M. (2004) "Compost Teas - causing a stir in horticulture". Delivered at a Henry Doubleday Research Association Members Conference at Ryton Organic Gardens, Coventry on 12 October 2004.

Litterick, A.M. (2004) "Organic horticultural production". Delivered at the Soil Association Highland Gathering in Inverness on 4/5 June, 2004.

Litterick, A.M. (2004) "Composts and compost teas - can they really help us improve crop health?" Delivered at the Horticultural Development Council/Soft Fruit Growers Association meeting at East Malling on 31 March.

Litterick, A.M. (2004) "Composts and manures - the muck and the magic!" Delivered at the Scottish BioDynamic Agricultural Association Members conference in Stonehaven on 13 March 2004.

GLOSSARY

Aerobic - in the presence of oxygen

Anaerobic - in the absence of oxygen

Compost - Solid particulate material that is the result of composting, that has been sanitized and stabilized and that confers beneficial effects when added to soil and/or used in conjunction with plants.

Composting - Process of controlled biological decomposition of biodegradable materials under managed conditions that are predominantly aerobic and that allow the development of thermophilic temperatures as a result of biologically produced heat, in order to achieve compost that is sanitary and stable.

Compost extract - the filtered product of compost mixed with any solvent (usually water), but not fermented. This term has been used in the past to define water extracts prepared using a very wide range of different methods. In the past, the terms “compost extract”, “watery fermented compost extract”, “amended extract”, “compost steepage” and “compost slurry” have all been used to refer to non-aerated fermentations. "Compost extract", "watery fermented compost extract" and "steepages" are approximate synonyms defined as a 1:5 to 1:10 (v:v) ratio of compost to water that is fermented without stirring at room temperature for

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a defined length of time. "Amended extracts" are compost extracts that have been fermented with the addition of specific nutrients or microorganisms prior to application.

Compost tea - The product of showering or circulating water through compost (or a porous bag of compost suspended over or within an open tank) with the intention of maintaining aerobic conditions. The product of this method has also been termed "aerated compost tea" and "organic tea".

In the past, the term "compost tea" has not always been associated with an aerated fermentation process. It is important to distinguish between compost teas prepared using aerated and non-aerated processes, therefore the terms aerated compost tea (ACT) and non-aerated compost tea (NCT) are used in this review to refer to the two dominant compost fermentation methods. ACT will refer to any method in which the water extract is actively aerated during the fermentation process. NCT will refer to methods where the water extract is not aerated or receives minimal aeration during fermentation apart from during the initial mixing.

Green and wood waste – vegetable waste from gardens and municipal parks, tree cuttings, branches, grass, leaves (with the exception of street sweepings), sawdust, wood chips and other wood waste not treated with heavy metals or organic compounds.

Growing medium - material other than soils *in situ*, in which plants are grown.

Humus - The more or less stable, dark coloured fraction of soil organic matter remaining after the major portions of added plant and animal residues have decomposed.

Manure – Animal excrement which may contain large amounts of bedding.

Maturity - Degree of biodegradation at which compost is not phytotoxic or exerts negligible phytotoxicity in any plant growing situation when used as directed.

Soil fertility - the capacity of the soil to support the crop being grown.

Soil health – the capacity of a specific kind of soil to function as a vital living system within natural or managed ecosystem boundaries, to sustain plant and animal productivity, to maintain or enhance water and air quality, and support human health and habitation.

Soil quality - the capacity of a soil to function within natural or managed ecosystem boundaries, to sustain biological productivity, maintain environmental quality and promote plant and animal health

Stabilization - Process of biological activities that together with conditions in the composting mass give rise to compost that is stable.

Stable, stabilized, stability - Degree of biodegradation at which the rate of biological activity under conditions favourable for aerobic biodegradation has slowed and microbial respiration will not resurge under altered conditions, such as manipulation of moisture and oxygen levels or temperature.

Vermicompost – The material that is egested from earthworms as casts, then further decomposed and matured in the vermicomposting system.

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The Compost Tea Industry Association (2004) http://www.composttea.org

The International Compost Tea Council (2004) http://www.intlctc.org